Promoting Student Independence with Project Based Labs

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Introduction

Hands-on, research based biology laboratories cultivate scientific thinking and allow students to participate in authentic activities of working scientists.[1] This project seeks to “throw away the cookbook” and to cultivate student responsibility, scientific thinking and time planning skills. A wiki was used to record and showcase student laboratory work, and to encourage student collaboration.

Plant Molecular Biology is an upper level elective in RIT’s Biotechnology program. Most students are seniors and will shortly be in graduate school or employment. This course encourages students to learn from their mistakes and to master some basic techniques used in molecular biology. Teams of 3-4 students researched, cloned and sequenced genes from *Arabidopsis thaliana*.

Student Projects

- Clone and sequence a gene from *Arabidopsis thaliana*
- Students supplied with an *Arabidopsis* plant, a gene number, basic reagents, biochemicals, protocols, laboratory equipment.
- Access to online data bases such as TAIR, NCBI, primer design tools, ApE (A Plasmid Editor- a free program for restriction digest prediction), and CodonCode, (sequence analysis).
- Lecture sessions focused on background, on-line resources, bioinformatics and database handling.
- Final presentation included screenshots from the wiki as well as research papers about each group’s gene.

Traditional Lab classes

Description

- Detailed instructions are given.
- Tasks are “cookie cutter”- simplified and tested by instructor.
- Each week planned ahead by instructor.
- Outcome is predictable.
- Easy to “leave behind” a failed experiment.

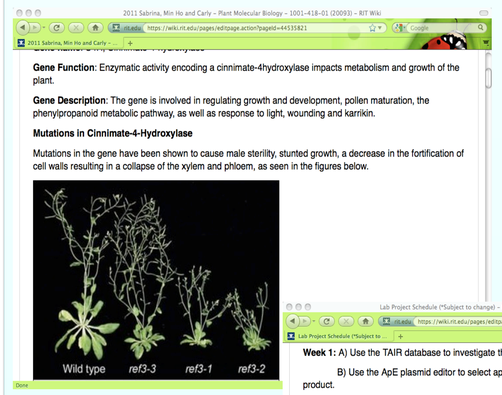
Student Behaviors

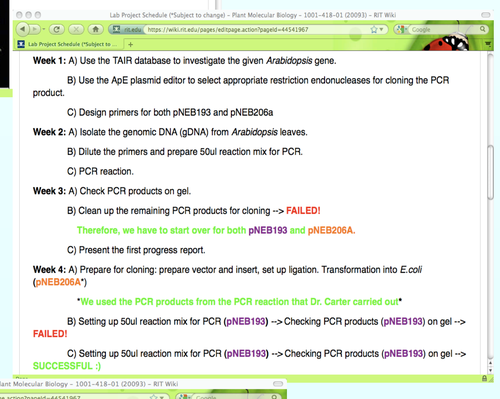
- Students tend to “auto-pilot” through laboratory exercises
- Lack of responsibility for “failed” experiments.
  - Instructor or prep staff are blamed.
- Little or no opportunity to troubleshoot problems.
- Little opportunity to refine and explore technical skills.

The Experiment

- Students were given an outline plan.
- Protocols were posted online, or on manufacturer websites.
- Basic reagents and biochemicals were supplied.
- Weekly progress reports (What are you doing today?).
- In class results recorded on paper (lab notebooks were not graded).
- Fair copy of results recorded on Plantwiki.
- Instructor posted comments to each group every week to monitor progress and help with problems.

Wiki Screen Shots




Lab Project Schedule (*Subject to change) – Plant Molecular Biology – 1001-418-01 (20093) – RIT Wiki

Week 1: A) Use the TAIR database to investigate the given *Arabidopsis* gene.

B) Use the ApE plasmid editor to select appropriate restriction endonucleases for cloning the PCR product.

C) Design primers for both pNEB193 and pNEB206a

Week 2: A) Isolate the genomic DNA (gDNA) from *Arabidopsis* leaves.

B) Dilute the primers and prepare 50ul reaction mix for PCR.

C) PCR reaction.

Week 3: A) Check PCR products on gel.

B) Clean up the remaining PCR products for cloning --> FAILED!

Therefore, we have to start over for both pNEB193 and pNEB206A.

C) Present the first progress report.

Week 4: A) Prepare for cloning: prepare vector and insert, set up ligation. Transformation into *E.coli* (pNEB206A*)

We used the PCR products from the PCR reaction that Dr. Carter carried out

B) Setting up 50ul reaction mix for PCR (pNEB193) --> Checking PCR products (pNEB193) on gel --> FAILED!

C) Setting up 50ul reaction mix for PCR (pNEB193) --> Checking PCR products (pNEB193) on gel --> SUCCESSFUL :)

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Week 5: A) Isolate and purify plasmid DNA (pNEB206A)

B) Prepare for cloning: prepare vector and insert. (pNEB193)

Week 6: A) Check for successful transformation by restriction digestions using EcoRI and HindIII (pNEB206A) --> FAILED!

B) Set up ligation. Transformation into *E.coli* (pNEB193)

Week 7: A) Check for successful transformation by restriction digestions using EcoRI and HindIII (pNEB206A) --> FAILED!

B) Check for successful transformation by restriction digestions using EcoRI and HindIII (pNEB206A) --> SUCCESSFUL :)

C) Isolate and purify plasmid DNA (pNEB193)

D) Check for successful transformation by restriction digestions using EcoRI and HindIII (pNEB193) --> FAILED!

E) Check for successful transformation by restriction digestions using EcoRI and HindIII (pNEB193) --> SUCCESSFUL :)

F) Present the second progress report.

Week 8: Preparation of sample to be sequenced.

Week 9: Sequence analysis and work on presentation.

Week 10: Presentation of the whole project.

Sequencing Analysis – Plant Mole...

Contig 1

Cinnimate-4-Hydroxylase Reference Genome

SCMpNEB193_M13R

SCMpNEB193_M13F

436 820 1,348 1,793

As seen in the figure above the forward strand overlaps the reference genome, obtained from Tair, from 436 to 1,348 which is 912 bps. While the reverse stand overlaps from 820 to 1,793 which is 973 bps.

According to the contig alignment 17 ambiguities were noted at the following positions in relation to the reference genome.

633, 834, 849, 867, 1112, 1222, 1250, 1281, 1288, 1310, 1321, 1328, 1335, 1475, 1731, 1732, & 1734

Learning Goals

- Student responsibility.
- Troubleshooting skills.
- Durable laboratory records.
- Time management skills.
- Precision and accuracy.
- Planning skills.
- Research skills

Challenges

- Some teams needed to repeat work outside of designated laboratory period.
- Some groups needed extensive instruction in basic techniques early in the project.
- Frustration at early failures required instructor-intervention to enhance morale and motivation.
- Project work does not allow for student absences!
- Students need initial training to get started on wiki entries

Student Comments

Q: This year’s lab section consisted of a self-paced project rather than weekly activities with detailed instructions. Which format do you prefer?

- I prefer detailed instructions when you first start out but a self paced project later in the quarter
- I think I learned more applicable information in the self paced project, because we had to deal with things not working rather than simply moving on to the next week’s activities without learning how to actually perform the technique correctly.
- The self-paced project was really useful because you couldn’t go on ‘autopilot ’with each weeks’ protocol. You had to look ahead and read each protocol and remain organized.

Q: Do you prefer writing up your results in a final report or posting them on the wiki?

- Posting on the wiki is more interactive, you can look at other groups and learn from their lab work

References

1. Vision and Change in Undergraduate Biology Education- A Call to Action. http://visionandchange.org/finalreport

Acknowledgements

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